Publication number : 62-054228

Date of publication of application : 09.03.1987

Int.Cl. G02F 1/133 G02F 1/13 G09F 9/35

Application number : 60-155836

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Date of filing : 15.07.1985

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MEHTOD FOR FABRICATING LIQUID CRYSTAL DISPLAY DEVICE

[Abstract]

PURPOSE: To execute filling work of the liquid crystal for a short time by decreasing the temperature of a substrate where a thin FLC is charged and laminated, after the substrate is preserved to the room temperature,

executing sealing by a plastic agent for sealing the peripheral part.

CONSTITUTION: An equal pressure is applied to the whole surface of a pair of substrates, and the liquid crystal is extended along the surface of a substrate 1 in the horizontal direction and laminated. The heater is gradually dropped to the room temperature, further, the first space 5 is also made into the air pressure, a cover 10' of a vacuum container 100 is removed, and the cell to laminate the liquid crystal between a pair of substrates is removed from the container. Thus, two facing substrates 1 and 1' are made into the condition to overlap mutually essentially a liquid crystal 3. Further, the substrate is reheated in accordance with the necessity, a sealing agent 9 for sealing is applied at the peripheral part and the mutual substrate is fixed.

SPECIFICATION

1 Title of the invention

MEHTOD FOR FABRICATING LIQUID CRYSTAL DISPLAY DEVICE

2. Claims

1. A method for fabricating a liquid crystal display (LCD) device having a liquid crystal cell in which each of a pair of bases with an electrode are installed facing each other and smectic liquid crystals are charged between the electrodes, wherein after the smectic liquid crystals are charged between the electrodes of the substrates, an edge portion of the pair of substrates is sealed.

2. The method of claim 1, wherein the smectic liquid crystals are ferroelectric liquid crystals.

3. The method of claim 1, wherein a gap between the electrodes is 4μm or below.

3. Detailed description of the Invention

[Field of the Invention]

The present invention relates to a method for fabricating a liquid crystal display (LCD) device and, more particularly, to a method for fabricating an LCD device capable of making a display part of a microcomputer, a word process or a TV set thin by installing a display panel using smectic liquid crystals (referred to hereinafter as 'Sm liquid crystals' or 'liquid crystals'), especially, for example, ferroelectric liquid crystals (referred to hereinafter as 'FLC').

[Description of the Prior art]

A solid display panel is effective for a large-scale display panel in controlling each pixel independently. As the solid display panel, a display device which employs a multiplexing driving method with a simple matrix structure of A4 plate size with horizontal 400 elements and vertical 200 elements by using 2 frequency liquid crystals, for example, twisted/nematic liquid crystals (referred to hereinafter as 'TN liquid crystals'), is widely known.

However, in fabricating the TN liquid crystals, since the TN liquid crystals has a low viscosity, when a pair of glass substrates are bonded, the glass substrates are placed to face with an interval of 5μ~10μ therebetween and then a sealant mixed with spacers is coated on an edge portion of the glass substrates to bond them. In this case, a portion of a seal portion of the edge portion is not sealed but remains as an opening. Thereafter, the pair of substrates with their edge portion sealed is maintained in a vacuum container and entirely vacuumized. And then, the opening is put in a TN liquid crystal solution and the interior of the vacuum container is allowed to have an atmospheric pressure in order to charge liquid crystals into the gap of 5μ~10μ between the substrates by using a capillary phenomenon.

[Problems to be solved by the Invention]

Such method is good when liquid crystals with the low viscosity such as the TN liquid crystals are charged between the substrates at a room temperature, but has many disadvantages in the following aspects.

That is, first, the method cannot be suitably employed in terms of its operation for the smectic liquid crystals with high viscosity, for example, the FLC which uses an SmC* layer.

Second, when the FLC is used on the premise that a gap between electrodes of a cell is 4μ or less, preferably, as narrow as 0.5μ~3μ, it takes much time to charge the FLC.

Third, when the FLC is charged on a large-scale plate, for example, on the A4 plate, it take long time, namely, 8 to 10 hours, at a high temperature, i.e., 120°C for charging the FLC. Thus, sealing of the edge portion can be degraded. In addition, the sealant can be mixed as an impurity into the liquid crystals.

Fourth, spacers (generally called 'scallop') which determine the cell gap can be inclined during the process of charging the liquid crystals.

Fifth, 90% of the liquid crystal material is not effectively used during charging, resulting in a waste of liquid crystals.

The present invention solves these problems.

[Means for solving the problem]

To achieve these and other advantages and in accordance with the purpose of the present invention, as embodied and broadly described herein, there is provided a method for fabricating an LCD device by using a so-called lamination method in which liquid crystals are put on one substrate, the other substrate is allowed to be tightly attached on the liquid crystals, the two substrates are mutually installed at a certain position. At the same time or in a follow-up process, sealing is made on an edge portion.

In addition, in the present invention, the smectic liquid crystals, and preferably, FLC having a smectic C phase (SmC*), are used. Namely, by making the cell gap 4μm or below, and generally, 0.5μm~3μm, a (both-side) stable state can be obtained.

That is, (isotropic) liquid crystals are dropped, spread or are coated at one or plural spots on a charge-subject surface of an electrode of one substrate, the other substrate is placed thereon.

The substrates are vacuumized and heated at their front and back side, pressed, and tightly attached respectively with FLC with the charge-subject surface installed on the inner side of each substrate with gap of 4μm or below therebetween. A temperature of the substrate on which the FLC has been charged and laminated is dropped to obtain an SmA and also a (both-side) stable SmC*. Then, a spiral structure can be released. And then, the substrates are maintained at a room temperature and sealed with a practical plastic sealant at their edge portion.

In the present invention, as for a usage temperature range, namely, the remaining problem, currently, a plurality of different FLCs can be combined (blended) and used at 0°C~50°C. Thus, the FLC can be practically used. And, referring to grey, if 8 colors are considered, the grey is not necessary, and it can be practically used for a display such as a microcomputer.

[Operation]

Accordingly, first, because a minimum cell gap is determined according to a size of spacers after spreading them, there is no non-uniformity in the gap of the formed FLC.

Second, even if the cell is thin with a gap of 4μm or below and has a large area (equivalent to A4 plate), the lamination operation can be preformed quickly.

Third, the FLC placed on the substrate can be effectively used by 100%.

Fourth, with the FLC with high viscosity, the lamination and sealing operation does not require one or more hours.

Fifth, even if an active device and an electrode connected with the active device are installed on one substrate, the FLC can be laminated in the same manner as a process of a passive structure which does not use the active device.

With such characteristics, in the present invention, the liquid crystal laminating method (which means narrowing the gap between the two sheets of substrates and putting the laminated liquid crystal therebetween) is employed, and the nonlinear element (NE) and the FLC are made in series to form each pixel, thereby obtaining a large-scale of A4 plate or larger matrix and driving each pixel without a cross talk therebetween.

[Embodiment of the invention]

Figure 1 illustrates a process of fabricating an LCD device in accordance with the present invention.

Figure 1A shows two substrates 1 and 1'. The substrates 1 and 1' have an electrode at the mutually facing surfaces 8 and 8' thereof. In order to display color, a color filter is installed between one electrode and the facing substrate or between one electrode and charge liquid crystals. And, as widely known, an asymmetrical alignment is performed on the surface of the electrode.

Though the two substrates are simply shown for the sake of simplification, the electrode, the filter, alignment processing, shadow processing (masking) for obtaining black matrix, and an active device can be formed or performed as necessary.

As the substrates, a glass substrate, e.g., a coning 7059, is generally used. And, among two substrates, one substrate or both substrates can be a flexible substrate. As the flexible substrate, a chemically strengthened glass substrate with a thickness of 0.3mm~6mm or a light transmissible heat-resistant organic resin substrate such as polyimide, PAN or PET can be also effectively used.

An alignment processing layer (asymmetrical alignment processing layer) is formed on the electrode of the substrate, and its surface is subject to be charged. And then, the FLC, e.g., S8 (octyl, oxy, benziriden, amino, methyl, butyl, benzoate), is installed on the surface. Besides, an FLC such as BOBAMBC or an FLC obtained by blending a plurality of types of liquid crystals can be charged. Herein, for example, liquid crystal obtained by blending S8 and B7 is used.

In addition, liquid crystals 2 are dropped on the charge-subject surface of one substrate. The pair of substrates with the liquid crystals installed therebetween are sealed in a vacuum container 100. The vacuum container 100 includes a first space in a container side 10 and a second space 5 in a cover side 10'. A heater 3 is installed in the first space 4. One substrate 1 is installed on the heater 3 and heated at a room temperature or at a certain temperature within 150°C, for example, at 70°C~150°C, e.g., 120°C, at which viscosity of the liquid crystals becomes sufficiently low.

Then, the liquid crystals 2 installed on the substrate 1 are heated. Before or after the liquid crystals were dropped to be placed, spacers are installed on the substrate with a certain gap. The spacers cannot be used.

The other substrate 1' facing the substrate 1 is disposed to be separated by 1mm~10mm such that they partially contact with each other lightly.

Thereafter, the cover container 10' having the second space 5 is adjusted to the container 10 by means of an O ring. The lower portion of the second space is shielded by a layer (called a silicon rubber 6) with elasticity with respect to the second space. As for a pressure of the second space and the first space, if the pressure of the first space has a positive pressure, the lower side is expanded, whereas if the pressure of the first space is a negative pressure, the rubber 6 is pulled up. The rubber is not limited to the silicon rubber so long as it can tolerate at least the temperature of 150°C.

After they are adjusted by the O ring, they are simultaneously vacuumized at the outlets 11 and 11'. Namely, the two outlets are connected with a vacuum pump 14 after passing trough valves 12 and 12'. The first and second spaces 4 and 5 are vacuumized by opening the valves 12 and 12' and closing valves 13 and 13'.

And then, as shown in Figure 1C, the other substrate is precisely installed on the surface of the substrate.

Thereafter, air or nitrogen is leaked gradually from the valve 13' so as to make the second space 5 have a positive pressure, compared with the first space 4, and obtain and the atmospheric pressure.

Then, as shown in Figure 1C, the silicon rubber 6 expands downwardly to press the other substrate 1' toward the substrate 1. In the atmospheric pressure, pressure of $1kg/cm^2$ can be applied. In case of giving more pressure by using nitrogen, pressure of 1 or more and $2\sim5kg/cm_2$ can be applied.

In this manner, the uniform pressure can be applied to the entire surface of the pair of substrates, which makes liquid crystals which have been placed at one or more spots spread on the surface of the substrate 1 in the horizontal direction, so as to be laminated.

The gap between electrodes of the pair of substrates can have the uniform thickness of 4μm or less, e.g., 2μm. If a spacer with a size of 2μm is previously installed, the thickness of the gap can be 2μm, and if spacers of 1μm spread in advance, the thickness of the gap can be 1μm.

As a matter of course, the spacer cannot be used, and liquid crystals can be laminated to a certain thickness by precisely controlling only the pressure and the heating temperature.

As a result, some liquid crystals are moved toward the edge portion. In this case, because the outer edge portion is covered by the silicon cover, overflowing of the liquid crystals outwardly of the outer edge portion of the substrate can be substantially prevented. In addition, overflowing of liquid crystals beyond the whole edge portion or shortage of liquid crystals for covering a desired region can be prevented by precisely controlling the initial supply amount of liquid crystal material.

As for overlapping of the two sheets of substrates in the X and Y directions, the substrates can be moved to be re-installed when the liquid crystals 3 have low viscosity when it is heated with the substrates 1 and 1'.

Thereafter, the heater was gradually dropped to a room temperature in Figure 1C. In addition, the first space 5 was adjusted to have the atmospheric pressure and the cover 10' of the vacuum container 100 is taken off. A cell obtained by laminating the liquid crystals between the pair of substrates as shown in Figure 1D is taken out. The two sheets of facing substrates 1 and 1' have the liquid crystals 3 overlapped therebetween.

With reference to Figure 1E, the substrates are re-heated as necessary, a sealant 9 (generally, a plastic material) is applied to their edge portion, and then, the substrates are bonded.

In this manner, the method for charging/laminating the liquid crystals with high viscosity like the smectic liquid crystals, especially, the FLC, is implemented between the substrates.

[Effect of the invention]

Accordingly, the amount of liquid crystals required to be used for one sheet of A4 plate (the area of 20cm x 30cm) can be 0.2cc enough, amounting to 2000 yen/g. That is, the liquid crystals more expensive than gold can be effectively used.

A short time, namely, about 1 hour, is taken to perform charging operation of the liquid crystals one time.

In spite of the large-scale substrate, the operation time cannot be lengthened.

That is, in the related art TN liquid crystal charging operation, the main interest is focused on not applying a stress to liquid crystals. Thus, the sealant on the edge portion of substrates support mutually with their force so as not to apply pressure, that may be applied from outside to the substrates, to liquid crystals themselves.

In this respect, however, as for the smectic liquid crystals, the inventors of the present invention have found that an external pressure applied to the liquid crystals does not matter thanks to the high viscosity of the smectic liquid crystals. Thus, such characteristics lead to accomplish the fabrication method of the present invention, which is completely different from any other related arts.

In the liquid crystal charging method in accordance with the present invention, the alignment processing layer constituting the charge-subject surface is asymmetrically aligned, namely, one portion is rubbed while the other portion is non-rubbed. In this case, after laminating, the substrates are slightly moved (1μ or more to 104μm) in a high temperature state according to the rubbed surface, and stress is applied to liquid crystals to align them.

As for the LCD device in accordance with the present invention, in case of a reflection type LCD device by installing a polarization plate at an outer side of one substrate or at both outer sides of the two substrates, an electrode at the side of substrate where light is made incident is made to be light-transmissible while an electrode at the other substrate is made a reflection type electrode. By having a tilt angle of the FLC as 4.5°, one sheet of filter can be installed on the substrate where light is made incident.

Meanwhile, in case of a transmission type or reflection type LCD device using two sheets of filters, two sheets of polarization plates are aligned at an outer side of each substrate and the tilt angel of the FLC is adjusted at about 22.5°. In the transmission type LCD device, a backlight unit can be irradiated by an EL (Electroluminescence) fluorescent lamp or a natural light, and the amount of transmitted light can be controlled for displaying an image.

In case of making color, preferably, a color filter is installed at an upper or lower portion of the electrode of the other substrate (namely, the substrate viewed by naked eyes).

In the present invention, a non-linear device is installed on the substrate and an electrode is installed at an upper portion of the non-linear device. Instead of the non-linear device, an active device can be used. As the non-linear device, an SCLAD (Space Charge Limitation Amorphous semiconductor Device) or an insulation gate type field effect semiconductor device having a composite diode structure such as NIN type can be used.

In the LCD device of the present invention, a photosensor using a write pen has a dot shape for displaying and reading.

The fabrication process of Figure 1 has a matrix construction of 100x100 (in case of color, 100x300).

However, the number of dots can be 640x400 (in case of color 1920x400) and 720x400, and other number of constructions.

[Description of drawings]

Figure 1 illustrates a method for fabricating a liquid crystal display (LCD) device in accordance with the present invention.